Microphone apparatus.

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Cited patent(s): US4589137; JP57015205; JP61194914

Abstract

A microphone apparatus having a microphone for producing a desired audio signal, and an adaptive signal processing section which is supplied as a reference signal with a vibration detected signal from a vibration detecting circuit for producing the vibration detected signal in response to a vibration of a vibration generating source whose vibration is picked up by the microphone and becomes an undesired noise signal, or a control signal for controlling a drive source of a driving unit of a recording apparatus for recording an output signal from the microphone and which reduces a noise signal contained in the audio signal.

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(54) Microphone apparatus.

(57) A microphone apparatus having a microphone for producing a desired audio signal, and an adaptive signal processing section which is supplied as a reference signal with a vibration detected signal from a vibration detecting circuit for producing the vibration detected signal in response to a vibration of a vibration generating source whose vibration is picked up by the microphone and becomes an undesired noise signal, or a control signal for controlling a drive source of a driving unit of a recording apparatus for recording an output signal from the microphone and which reduces a noise signal contained in the audio signal.

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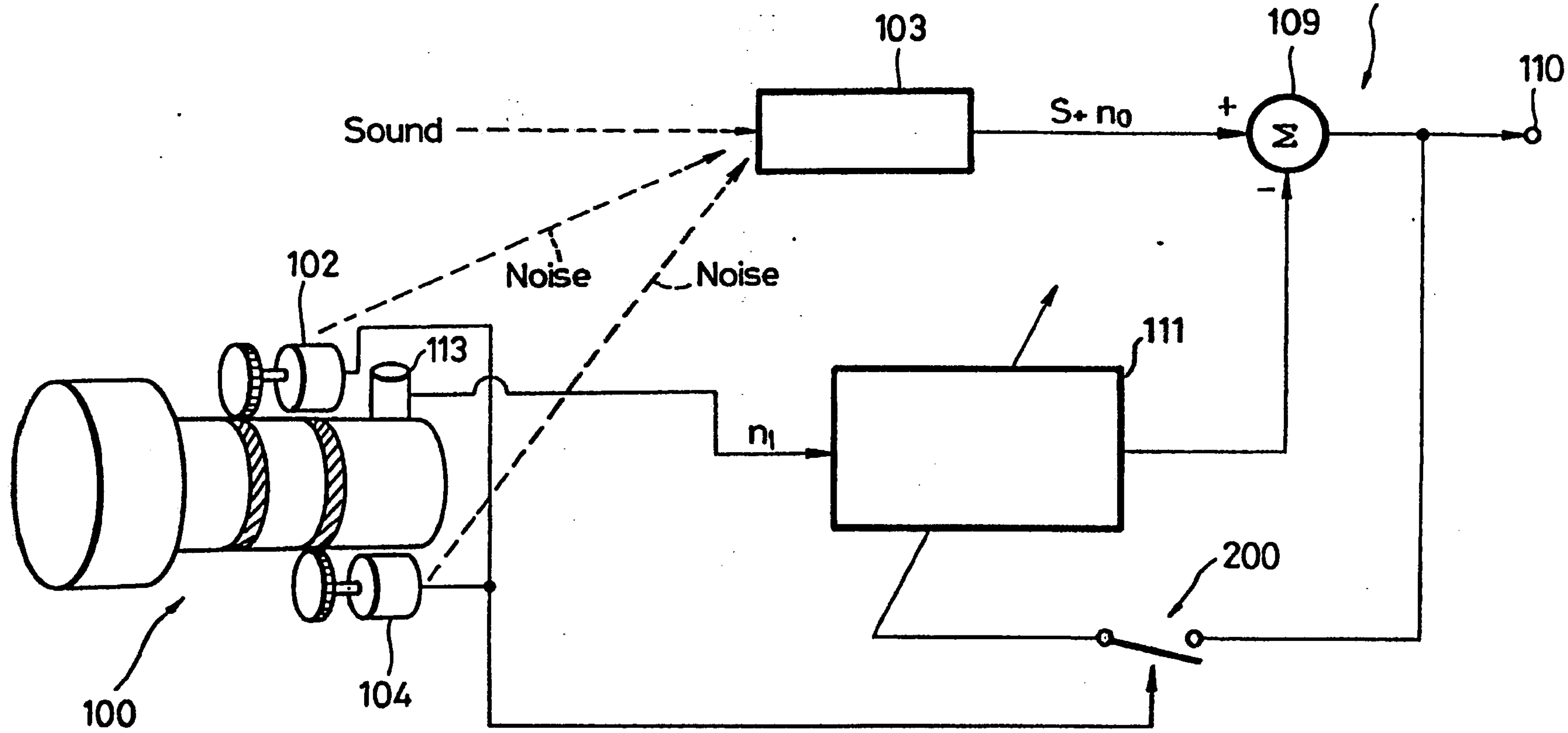
F/G. 2



Sound
103
S+ n0
+
Σ
109
101
110
−
Noise
Noise
102
113
n1
111
200
100
104

The present invention generally relates to microphones and, more particularly, is directed to a microphone apparatus suitable for reducing undesired noise signals by adaptive signal processing.

In equipment which has a built-in microphone, such as a video tape recorder having a built-in type camera or the like, the microphone has a tendency to pick up unnecessary noise signals generated within the equipment (its mechanical system) or from outer vibration generating sources, in addition to the desired audio signal.

That is, the microphone may pick up vibration (internal vibration) of a driving section of the video tape recorder, producing noise in the recording. As another example, when a recorder is placed on a desk and when any vibration (external vibration) is applied to the desk, the vibration is picked up as noise.

To solve this problem, the microphone is designed to have directivity with a low sensitivity to extraneous noise and is mounted to be positioned as far as possible from the noise source. However, since the reduction in noise is not complete, the noise may still be audible in the recording. Also, when an external vibration is directly applied to the microphone, that vibration is picked up as noise.

To overcome this disadvantage, it is known to use adaptive signal processing, in which the noise signal picked up and produced from the microphone is electrically processed and reduced. As will be understood from figure 1 of the accompanying drawings, an adaptive filter 11 used in the adaptive signal processing includes (K-1) delay elements (for every clock) 20 .. and K variable amplifiers 30 .... The first amplifier 30 (leftmost one in figure 1) is directly supplied with a reference signal n_1 and the succeeding amplifiers 30 are respectively supplied with the reference signal n_1 through the associated delay elements 20.

Assuming that W_k is the coefficient of the adaptive filter 11 and also assuming that t is time and that t-1 is the time of the preceding clock period, then the following equation (1) will be established between coefficients $W_{k,t}$ and $W_{k,t-1}$:

$$W_k = W_{k,t-1} + 2\mu e_{t-1} \times N_{1k,t-1} \quad (1)$$

Then, the coefficients W_k are changed, and each time they are changed, a filter associated with the reference signal n_1 is formed.

The adaptive filter 11 is proposed in [B Widrow and S D Stearns: "Adaptive Signal Processing", Prentice-Hall, 1985], [Digital signal processing - advanced course, <adaptive signal processing>, Journal of 35th Technical Lecture Meeting held by Acoustical Society of Japan], etc.

In the adaptive signal processing, however, the amount of noise signal reduction depends on a reference signal necessary for such processing, and thus there is a problem of how to select the reference signal.

Accordingly, it is an object of the present invention to provide an improved microphone apparatus in which the aforenoted shortcomings and disadvantages of the prior art can be eliminated.

A first aspect of the invention provides a microphone apparatus comprising:

a microphone for producing a desired audio signal;

vibration detecting means for producing a vibration detected signal in response to a vibration of a vibration generating source which generates a vibration picked up by said microphone to produce an undesired noise signal; and

an adaptive signal processing section arranged to be supplied with said vibration detected signal as a reference signal and operative to reduce said noise signal contained in said audio signal.

A second aspect of the invention provides a microphone apparatus comprising:

a microphone for supplying a desired audio signal to a recording apparatus having a driving unit; and

an adaptive signal processing section for reducing an undesired noise signal of noise generated from said driving unit, picked up and produced by said microphone on the basis of a predetermined 'reference signal, wherein said adaptive signal processing section is arranged to be supplied with a control signal supplied to a driving source of said drive unit as said reference signal.

A third aspect of the invention provides a recording apparatus having a recording mechanism for recording an output signal from a microphone, comprising:

vibration detecting means for producing a vibration detected signal in response to a vibration of a vibration generating source which generates a vibration picked up by said microphone to produce an undesired noise signal; and

an adaptive signal processing section arranged to be supplied with said vibration detected signal as a reference signal and operative to reduce said noise signal contained in said audio signal.

A fourth aspect of the invention provides a recording apparatus having a recording mechanism for recording an output signal from a microphone comprising:

an adaptive signal processing section for reducing an undesired noise signal of noise generated from said recording mechanism, picked up and produced by said microphone on the basis of a predetermined reference signal, wherein said adaptive signal processing section is arranged to be supplied with a control signal supplied to a driving source of said recording mechanism as said reference signal.

The invention will be further described by way of non-limitative example with reference to the accompanying drawings, in which:-

Figure 1 is a conceptual diagram of an adaptive filter, and to which references will be made in exp-

laining function or the like of this adaptive filter;

Figure 2 is a schematic diagram showing an arrangement of a first embodiment of a microphone apparatus according to the present invention;

Figure 3 is a schematic diagram showing an arrangement of a second embodiment of a microphone apparatus according to the present invention;

Figure 4 is a schematic diagram showing an arrangement of a third embodiment of the microphone apparatus according to the present invention;

Figure 5 is a correlative diagram showing a spectrum provided when a video tape recorder having a built-in camera is in the recording mode;

Figure 6 is a correlative diagram showing a spectrum of a signal n_1;

Figure 7 is a correlative diagram showing a spectrum of a signal processed by an adaptive signal processing circuit;

Figure 8 is a schematic diagram showing an arrangement of a fourth embodiment of the microphone apparatus according to the present invention;

Figure 9 is a schematic diagram used to explain a noise signal and a reference signal;

Figure 10 is a correlative diagram showing a spectrum provided when a video tape recorder having a built-in camera is in the recording mode;

Figure 11 is a correlative diagram showing a spectrum of the signal n_1;

Figure 12 is a correlative diagram showing a spectrum of a signal processed by an adaptive signal processing circuit; and

Figure 13 is a schematic diagram showing an arrangement of a fifth embodiment of the microphone apparatus according to the present invention.

The preferred embodiments of the microphone apparatus according to the invention will now be described with reference to the accompanying drawings.

Figure 2 generally shows a schematic block diagram of a microphone apparatus 101 to which the present invention is applied. A microphone 103 picks up a desired sound such as human voice and or the like produces an audio signal S, and the microphone 103 also picks up noise (vibration) generated from a vibration generating source and produces a noise signal n_0.

The audio signal S and the noise signal no are mixed and supplied to an adder 109, and the output of the adder 109 is supplied to a recording system, not shown, through a terminal 110 and also to an adaptive filter 111.

Vibration may generally be generated when the drive unit of, for example, a video tape recorder having a built-in camera in which the above mentioned microphone apparatus 101 is provided is operated (vibration is generated from internally by the mechanism); and when a vibration is applied to a desk on which the microphone apparatus 101 is placed (eg, if a person taps the desk, a vibration is generated from the outside).

Accordingly, vibration detecting means (pickup) 113 formed of piezoelectric elements or the like which respond to the vibration from the vibration generating source to generate a vibration detected signal n_1 is located as shown in figures 2 and 3 at a position so as to detect the vibration generated from the inside, for example, from an auto-focusing motor 102 and a zooming motor 104 of, for example, the video tape recorder having a built-in camera 100 (ie, near the motor or the gear), and as shown in figure 4 at a position to detect the vibration generated from the outside, or the desk 106.

As will be understood from figure 5, when the video tape recorder having a built-in camera 100 is in the recording mode (pickup 113 is mounted on a flexible board mounted on a rotary drum), a noise signal n_0 having a spectrum having peak values A_1, A_2, A_3 and A_4 is generated. The spectrum of the signal n_1 produced from the output of the pickup 113 has a plurality of peak values A_1, A_2, A_3 and A_4 as shown in figure 6. However, these peak values are removed by the adaptive signal processing in the adaptive filter 111 or the like (adaptive signal processing unit) from the spectrum of the noise signal n_0 which is produced from the video tape recorder having a built-in camera 100 as will be understood from figure 7.

As described above, according to the above embodiments, the output signal n_1 of the pickup 113 is used as the reference signal n_1 so that the peak values A_1, A_2, A_3 and A_4 of the noise signal n_0 are removed by the adaptive signal processing unit such as the adaptive filter 111 or the like.

Consequently, the noise signal n_0 can be properly reduced and thus, the audio signal can be satisfactorily reproduced.

As will be seen from figures 2 and 3 which shows the first and second embodiments of the present invention, when the pickup 113 detects the vibration of the auto-focusing motor 102 or the zooming motor 104, a switch 200 is interposed between the output terminal of the adder 109 and the input terminal of the adaptive filter 111 and the switch 200 is closed only when the auto-focusing motor 102 or the zooming motor 104 is driven. Thus, since the adaptive signal processing is effected only when the motor 102 or the motor 104 is driven, the sound of the auto-focusing drive anti of the zoom drive can be reliably removed and useless power consumption is suppressed, and the adaptive signal processing is effectively performed.

In addition, if an attempt were made to reduce noise signal n_0, for example, in an analog circuit, the

gain adjustment in the microphone 103 and the pickup 113 would be difficult, and the noise signal n_0 would not be reduced enough if the adjustment were inappropriate. However, in this embodiment, the adaptive signal processing is performed so that the noise signal n_0 can be easily and reliably reduced.

Further, even though the reproduced sound from the speaker contains, for example, both musical sound and noise, it is frequently observed that human auditory sense cannot distinguish the noise from the musical sound if the volume of the musical sound exceeds a certain level.

Therefore, in this case, the adaptive signal processing is not necessarily made and the adaptive signal processing may be performed only when the level of musical sound, or the level of the audio signal S is below a certain level.

In other words, the adaptive signal processing may be performed only when the level of the audio signal (containing the noise signal n_0) is below a certain "threshold value" and the level of the "threshold value" may be properly selected or set in accordance with the kind (human voice, music and so on) of the audio signal S or the like.

As will be understood from figure 3, in this case, the output of the microphone 103 is supplied to a level detector 150, wherein the level thereof is detected, and the output of the level detector 150 is supplied to an amplifier 160, changing the amplification factor μ of the amplifier 160.

The output ϵk of the adder 109 is amplifier into $\mu\epsilon k$ by the amplifier 160 and then fed to the adaptive filter 111 through the switch 200.

In that case, if the detected level is large, the amplification factor μ is made small, while if the level is small, the amplification factor μ is made large.

According to the above arrangement, only when the level detector 150 detects that the level of the signal [S + n_0] is smaller than a certain threshold value, is adaptive signal processing performed by the adaptive filter 111 or the like.

Accordingly, this embodiment achieves substantially the same effect as that of the first embodiment, and since no useless power is consumed or the like, the adaptive signal processing is effectively performed.

In this case, the switch 200 need not always be provided.

On the other hand, as will be seen from figure 4, the arrangement of the third embodiment in which the pickup 113 detects the vibration of the desk 106 is effective when the desk 106 is tapped and so on or particularly when an inadvertent vibration is produced as the noise signal n_0 from the microphone 103.

That is, although such a case may occur that the main audio signal S, cannot be distinguished due to the inadvertent noise signal n_0, by supplying the output signal of the pickup 113 to the adaptive filter 111 as the reference signal n_1, the noise signal n_0 can be almost completely removed, thus the audio signal S being satisfactorily reproduced.

Other embodiments of the microphone apparatus according to the present invention will now be described with reference to the following drawings.

Figure 8 generally shows a schematic diagram of a fourth embodiment of the microphone apparatus 201 according to the present invention.

As shown in figure 8, a microphone 203 picks up a desired sound such as human voice or the like from a sound generating source 205 and produces an audio signal S. The microphone 203 also picks up noise generated from a mechanical system 207 and produces a noise signal n_0.

The audio signal S and the noise signal n_0 are added and supplied to an adder 209, and an output of the adder 209 is supplied through a terminal 210 to a recording system not shown and also to an adaptive filter 211.

A control signal n_1 is used to control a drum drive motor (drive source) of the mechanical system 207 of a video tape recorder having a built-in camera or the like and supplied from a drive source control signal providing circuit 213 to the motor of the mechanical system 207 and also to the adaptive filter 211.

In that case, the motor is controlled by three-phase electrical signals U, V and W as will be seen from figure 9, and a signal (trapezoidal wave), which results from mixing these signals U, V and W via resistors R (100 kΩ), is supplied to the adaptive filter 211 as a reference signal n_1, thereby the adaptive filter 211 producing an output of opposite phase, which is fed to the adder 209.

The reference signal n_1 may be a counter electromotive force of the mixed signal of the three signals U, V and W.

As seen from figure 10, when the video tape recorder having a built-in camera is in the recording mode, a noise signal n_0 of a spectrum having peak values A_1, A_2, A_3 and A_4 is produced, and a spectrum of the mixed signal n_1 has a plurality of peak values as seen from figure 11. However, as a result of the adaptive signal processing in the adaptive filter 211 (adaptive signal processing unit) or the like, the peak values A_1, A_2, A_3 and A_4 are removed from the spectrum of the noise signal n_0 from the video tape recorder having a built-in camera as will be understood from figure 12.

As described above, according to the fourth embodiment, the motor control signal is used as the reference signal n_1 and the peak values A_1, A_2, A_3 and A_4 of the noise signal n_0 are removed by the adaptive signal processing unit such as the adaptive filter 211 or the like. As a result, the noise signal n_0 is properly reduced and thus the audio signal is satisfactorily reproduced.

A fifth embodiment of the microphone apparatus

according to the present invention will be described with reference to figure 13. In figure 13, like parts corresponding to those of figure 8 are marked with the same references and therefore need not be described in detail.

As noted above, even though the reproduced sound from the speaker contains, for example, both musical sound and noise, the human auditory sense generally cannot distinguish the noise from the musical sound if the volume of the musical sound exceeds a certain level.

Accordingly, in such case, the adaptive signal processing need not necessarily be made and it is also appropriate to perform the adaptive signal processing only when the level of musical sound or the level of the audio signal S is below a certain level.

Therefore, according to the fifth embodiment, the adaptive signal processing is performed only when the level of the audio signal (containing the noise signal n_0) is below a certain threshold value.

In that case, the level of the threshold value is properly selected or set in accordance with the kind (human voice, music and so on) of the audio signal S.

As will be seen from figure 13, in the fifth embodiment, the output of the microphone 203 is supplied to a level detector 215, wherein the level thereof is detected, and the output of the level detector 215 is supplied to an amplifier 217, changing the amplification factor μ of the amplifier 217. Then, the output ϵk of the adder 209 is amplified into $\mu\epsilon k$ by the amplifier 217 and supplied to the adaptive filter 211.

In this case, if the detected level is large, the amplification factor μ is made small, while if the detected level is small, the amplification factor μ is made large.

According to the above arrangement, only when the level detector 215 detects that the level of the signal [S + n_0] is smaller than a certain threshold value, the adaptive signal processing is performed by the adaptive filter 211 or the like.

Accordingly, this embodiment has the same effect as that of the preceding embodiments, and since no useless power or the like is consumed, the adaptive signal processing can be performed effectively.

While in the above embodiments the present invention has been described applied to the video tape recorder having a built-in camera and also the auto-focusing motor, the zoom motor or the mechanical unit as the example of the vibration generating source, the present invention is not limited thereto and may be applied to a standard tape recorder.

According to the microphone apparatus of the present invention, as will be understood from the above description, the vibration detected signal of the vibration from the vibration generating source which generates noise within or exterior to the recorder is used for the reference signal, and the adaptive signal processing is performed.

Therefore, an unnecessary noise signal is sufficiently removed, thus the noise signal being properly reduced.

Furthermore, in the microphone apparatus of the present invention, the drive source control signal of the recorder is used for the reference signal to thereby perform the adaptive signal processing. Therefore, the unnecessary noise signal is reduced to a sufficient degree and thus the noise is properly reduced.

Claims

1. A microphone apparatus comprising:
   a microphone for producing a desired audio signal;
   vibration detecting means for producing a vibration detected signal in response to a vibration of a vibration generating source which generates a vibration picked up by said microphone to produce an undesired noise signal; and
   an adaptive signal processing section arranged to be supplied with said vibration detected signal as a reference signal and operative to reduce said noise signal contained in said audio signal.

2. A microphone apparatus according to claim 1, further comprising control means for controlling operation of said adaptive signal processing section in response to the level of an output signal from said microphone.

3. A microphone apparatus according to claim 2, wherein said control means control said adaptive signal processing section such that said adaptive signal processing section is operated when the level of the output signal from said microphone becomes smaller than a predetermined threshold value.

4. A microphone apparatus comprising:
   a microphone for supplying a desired audio signal to a recording apparatus having a driving unit; and
   an adaptive signal processing section for reducing an undesired noise signal of noise generated from said driving unit, picked up and produced by said microphone on the basis of a predetermined reference signal, wherein said adaptive signal processing section is arranged to be supplied with a control signal supplied to a driving source of said drive unit as said reference signal.

5. A microphone apparatus according to claim 4, further comprising control means for controlling

operation of said adaptive signal processing section in response to the level of an output signal from said microphone.

6. A microphone apparatus according to claim 5, wherein said control means is operative to control said adaptive signal processing section such that said adaptive signal processing section is operated when the level of the output signal from said microphone becomes smaller than a predetermined threshold value.

7. A recording apparatus having a recording mechanism for recording an output signal from a microphone, comprising:
vibration detecting means for producing a vibration detected signal in response to a vibration of a vibration generating source which generates a vibration picked up by said microphone to produce an undesired noise signal; and
an adaptive signal processing section arranged to be supplied with said vibration detected signal as a reference signal and operative to reduce said noise signal contained in said audio signal.

8. A recording apparatus according to claim 7, further comprising control means for controlling operation of said adaptive signal processing section in response to the level of an output signal from said microphone.

9. A recording apparatus according to claim 8, wherein said control means is operative to control said adaptive signal processing section such that said adaptive signal processing section is operated when the level of the output signal from said microphone becomes smaller than a predetermined threshold value.

10. A recording apparatus according to claim 10, wherein said noise detecting means is provided in the vicinity of a driving source which drives a moveable unit of said recording apparatus.

11. A recording apparatus having a recording mechanism for recording an output signal from a microphone comprising:
an adaptive signal processing section for reducing an undesired noise signal of noise generated from said recording mechanism, picked up and produced by said microphone on the basis of a predetermined reference signal, wherein said adaptive signal processing section is arranged to be supplied with a control signal supplied to a driving source of said recording mechanism as said reference signal.

12. A recording apparatus according to claim 11, further comprising control means for controlling operation of said adaptive signal processing section in response to the level of an output signal from said microphone.

13. A recording apparatus according to claim 12, wherein said control means is operative to control said adaptive signal processing section such that said adaptive signal processing section is operated when the level of the output signal from said microphone becomes smaller than a predetermined threshold value.

14. A recording apparatus according to claim 13, wherein said drive source is a motor and said reference signal is a control signal which is supplied to said motor.

FIG. 1

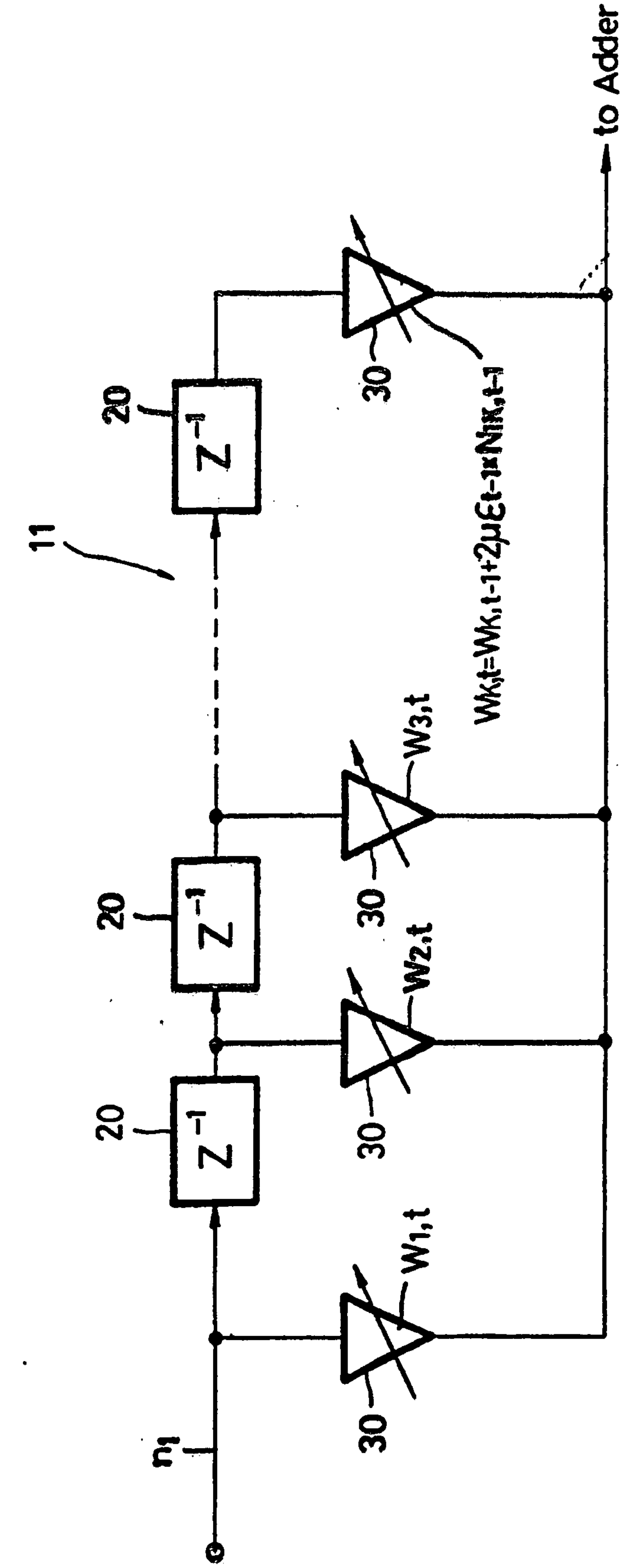
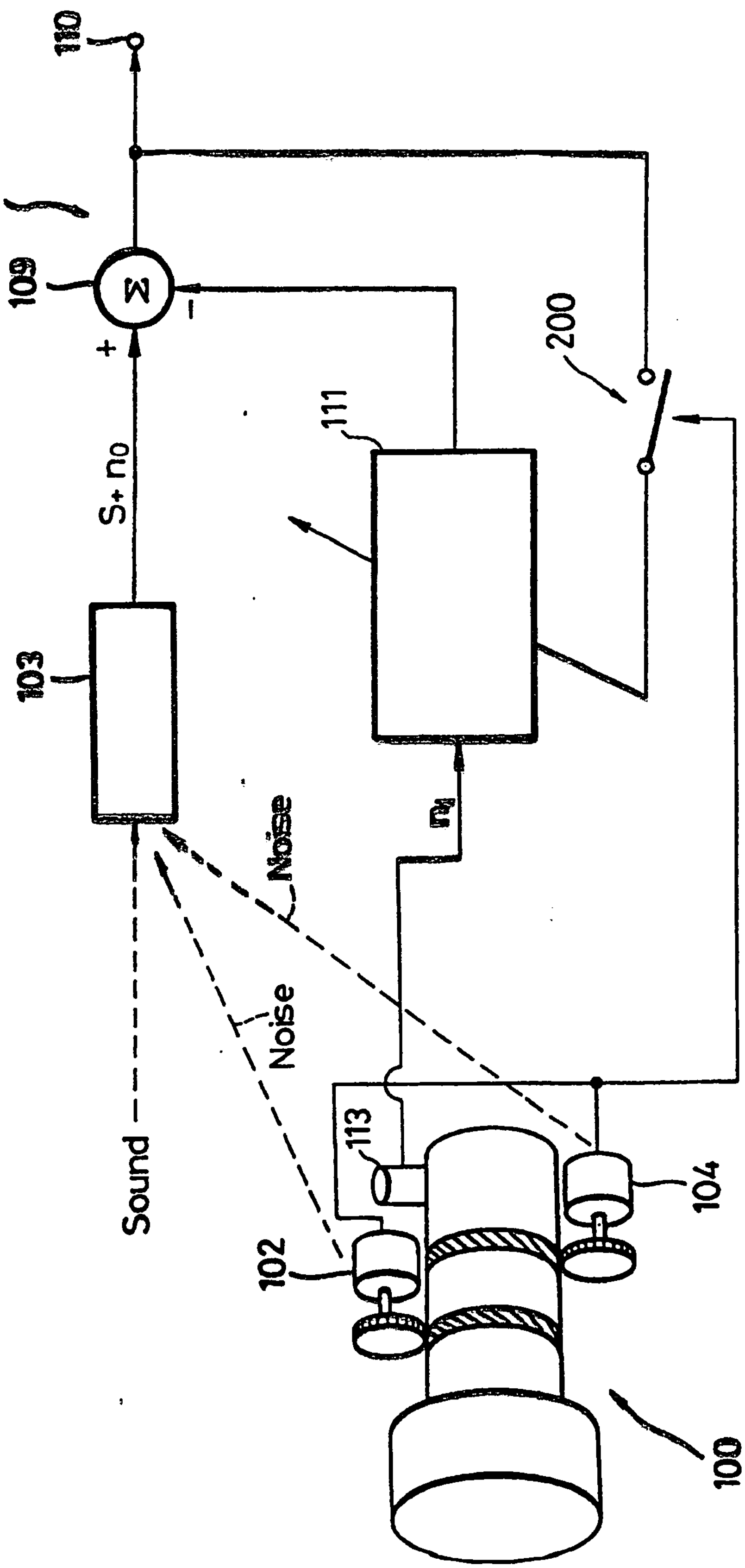


FIG. 2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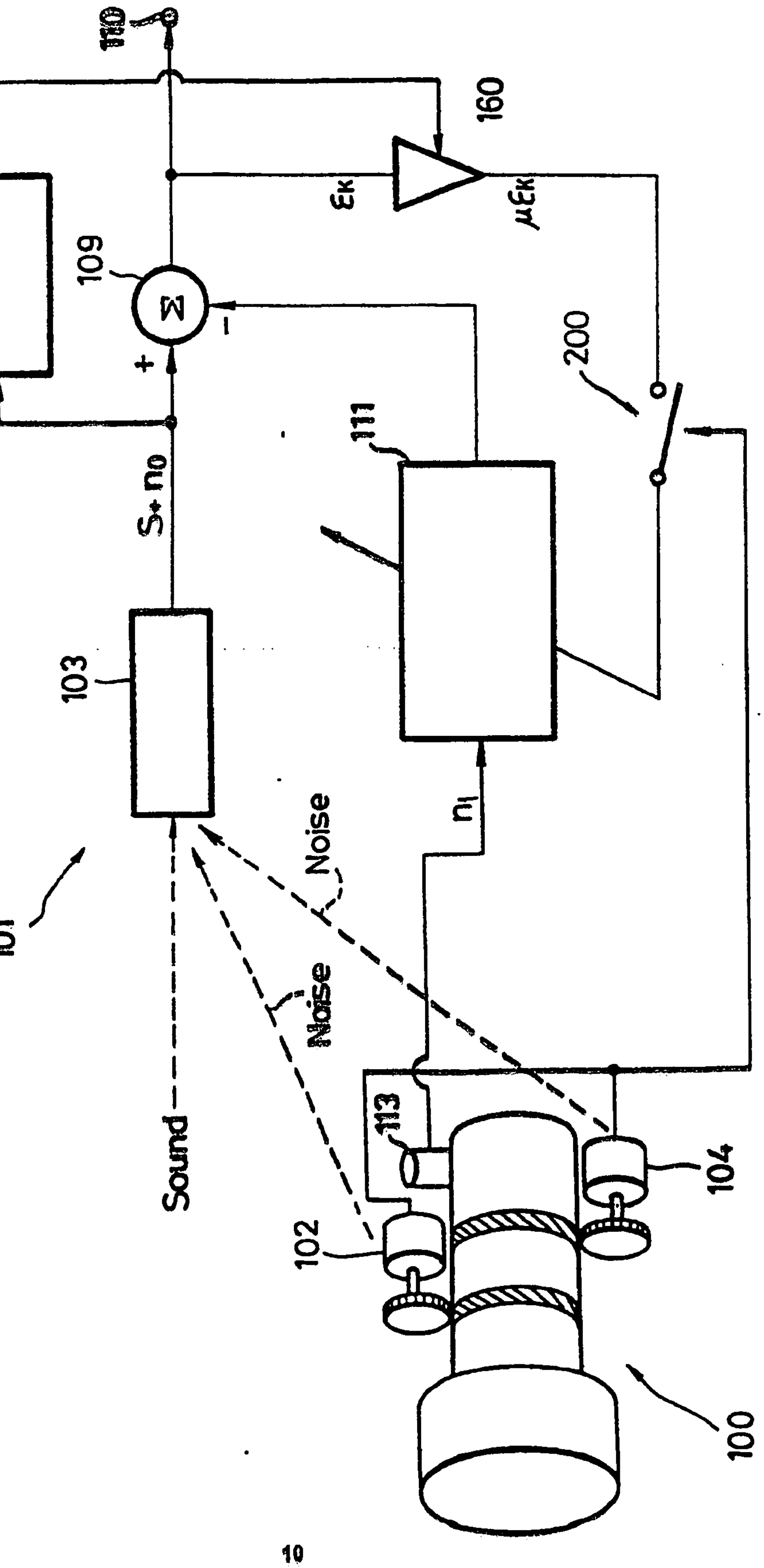
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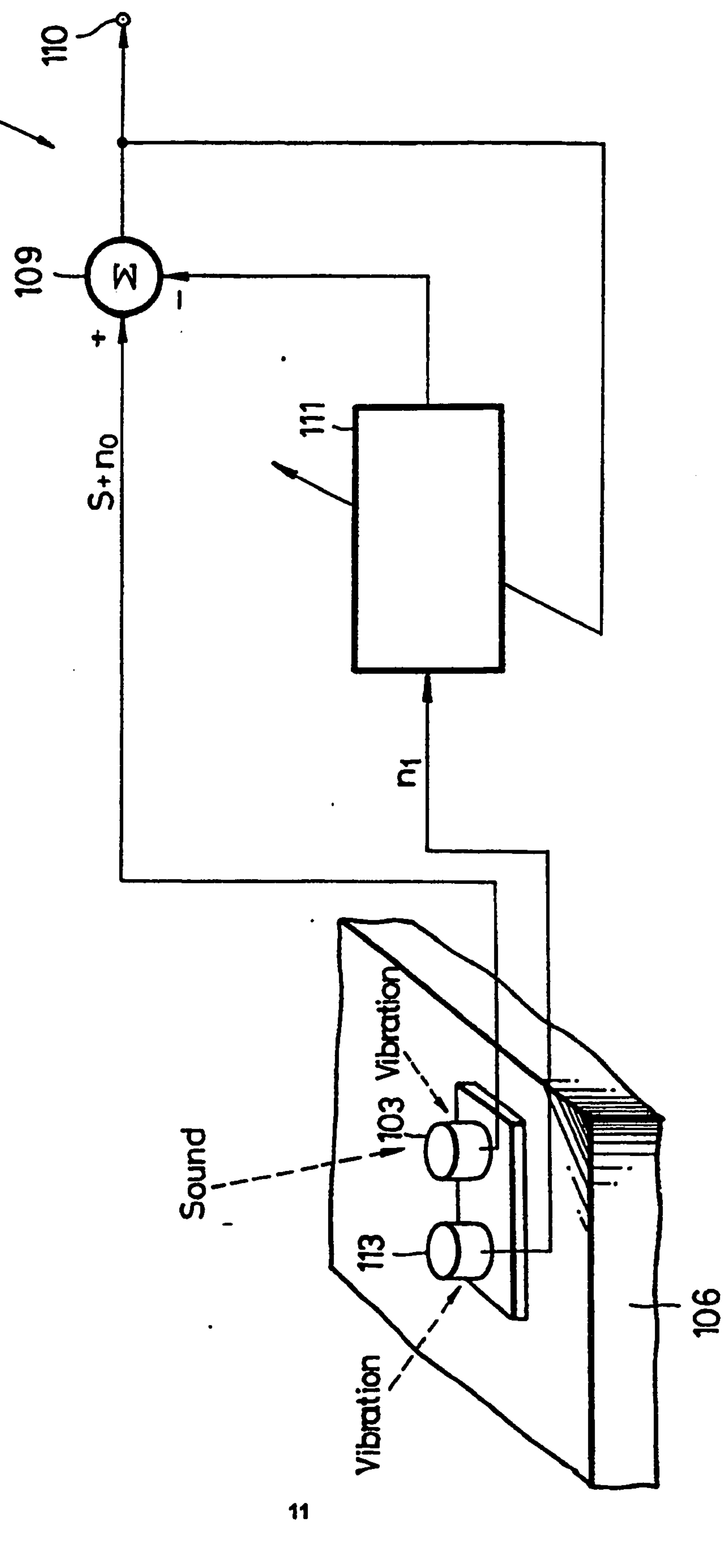
F I G. 3

FIG. 4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111
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Vibration
Sound
113
Vibration
106

FIG. 5

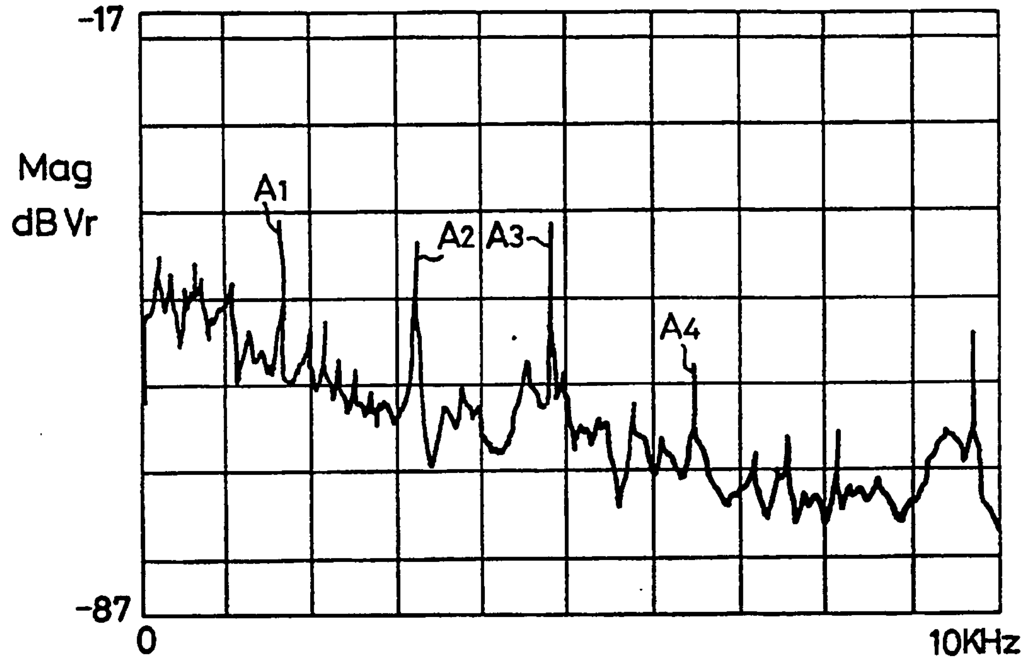


FIG. 6

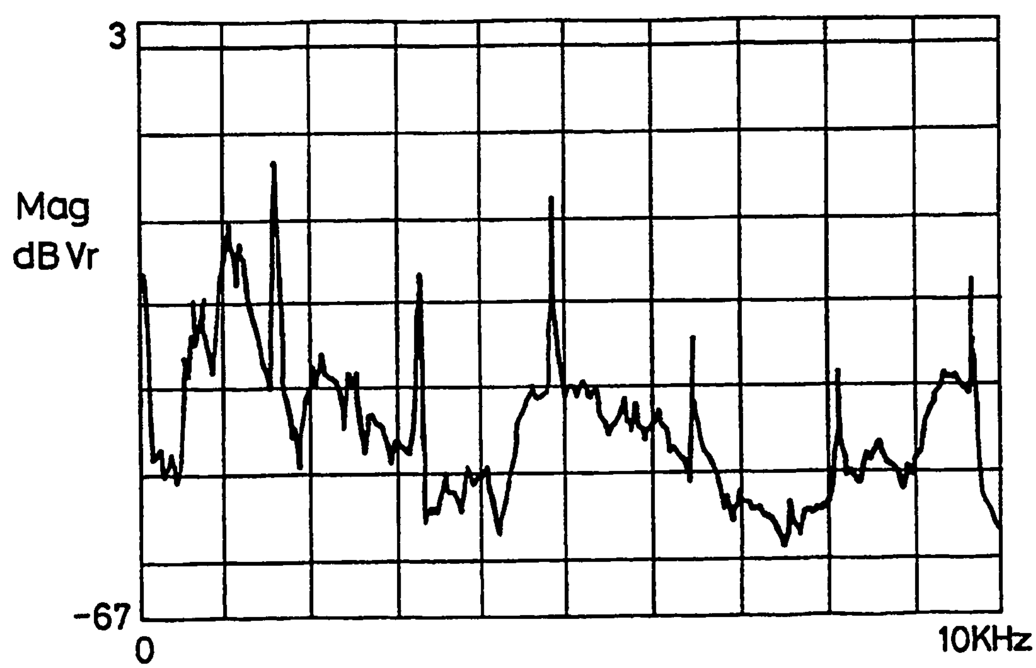


FIG. 7

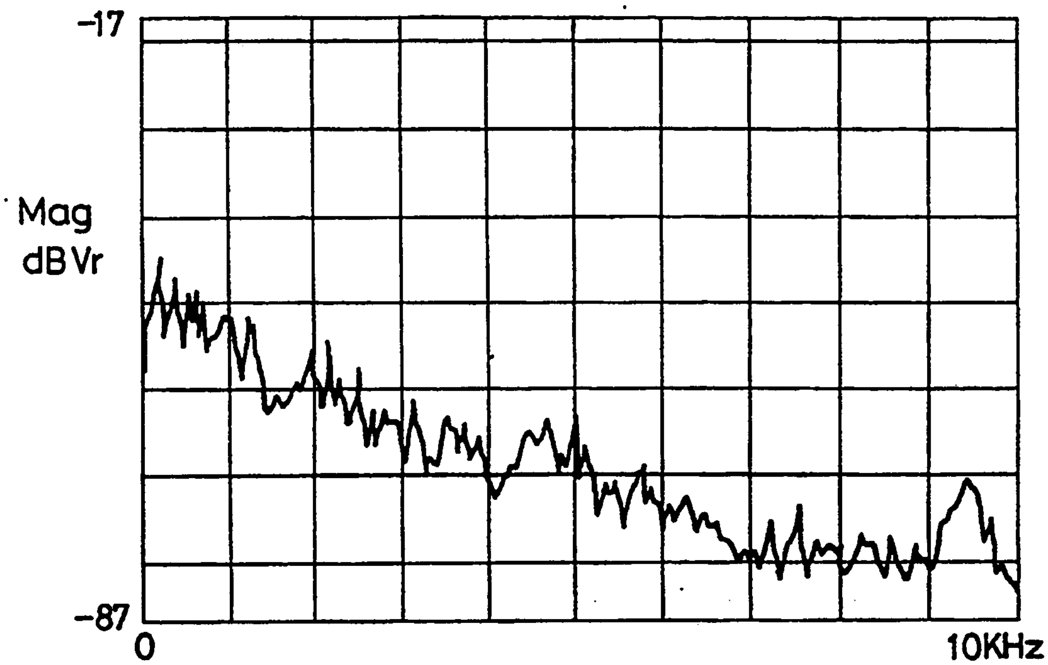
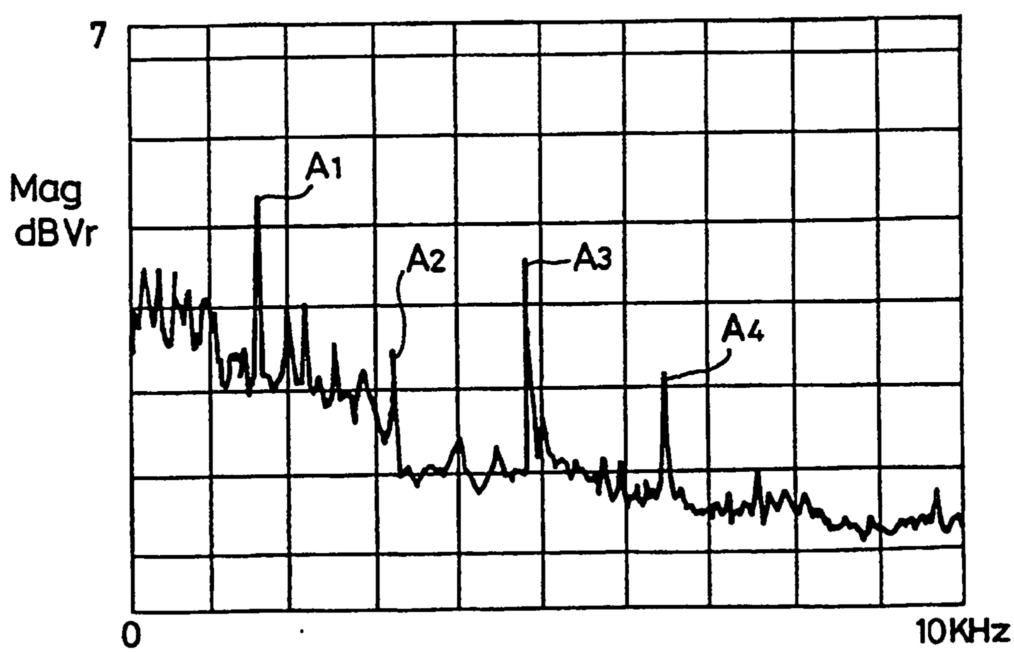


FIG. 10



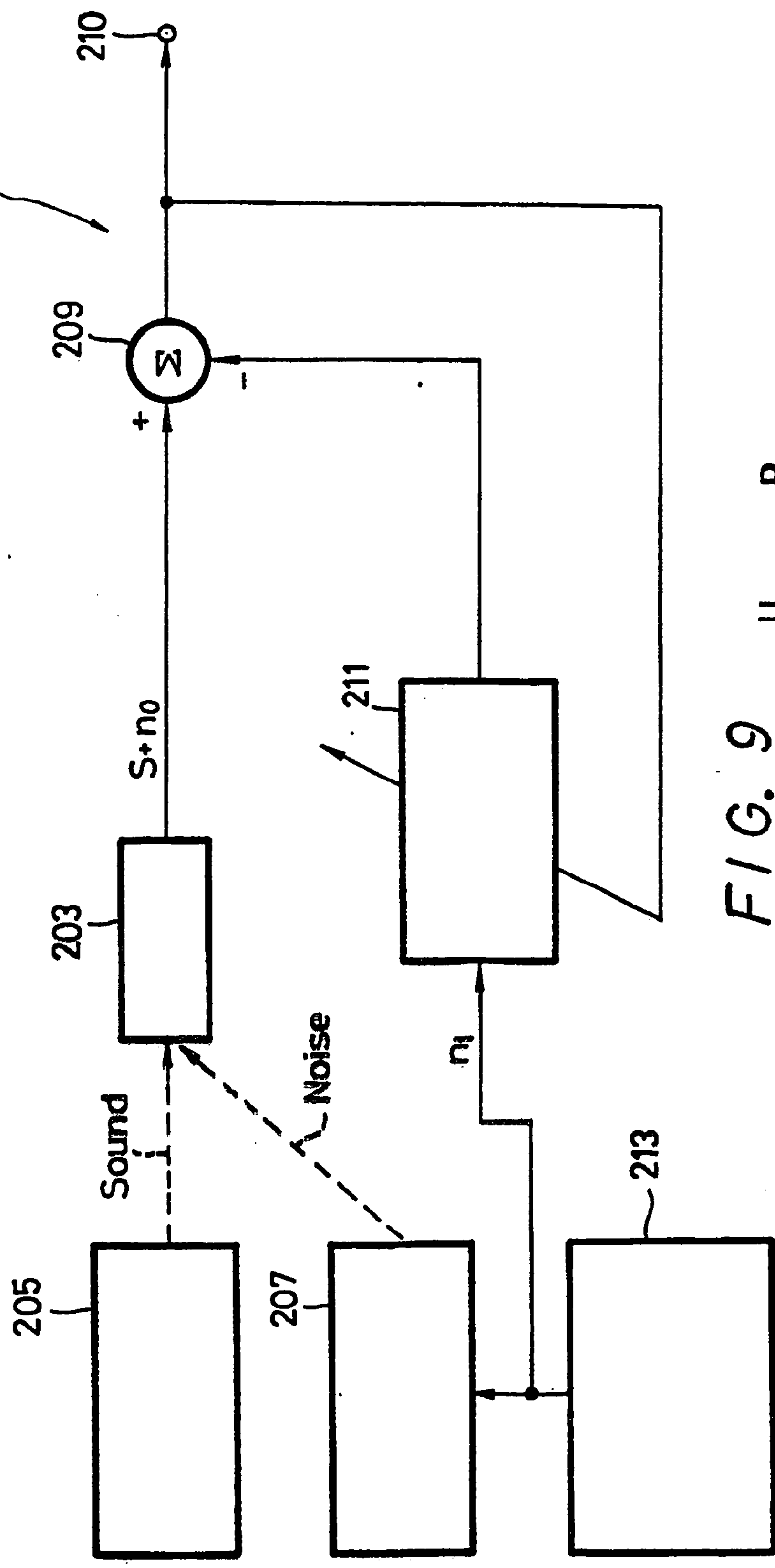


FIG. 8

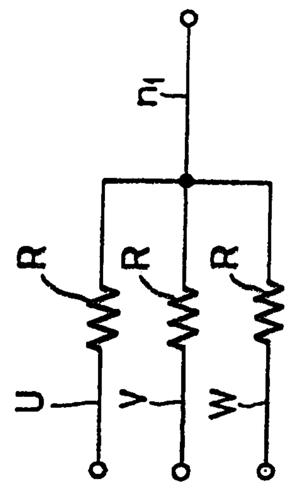


FIG. 9

FIG. 11

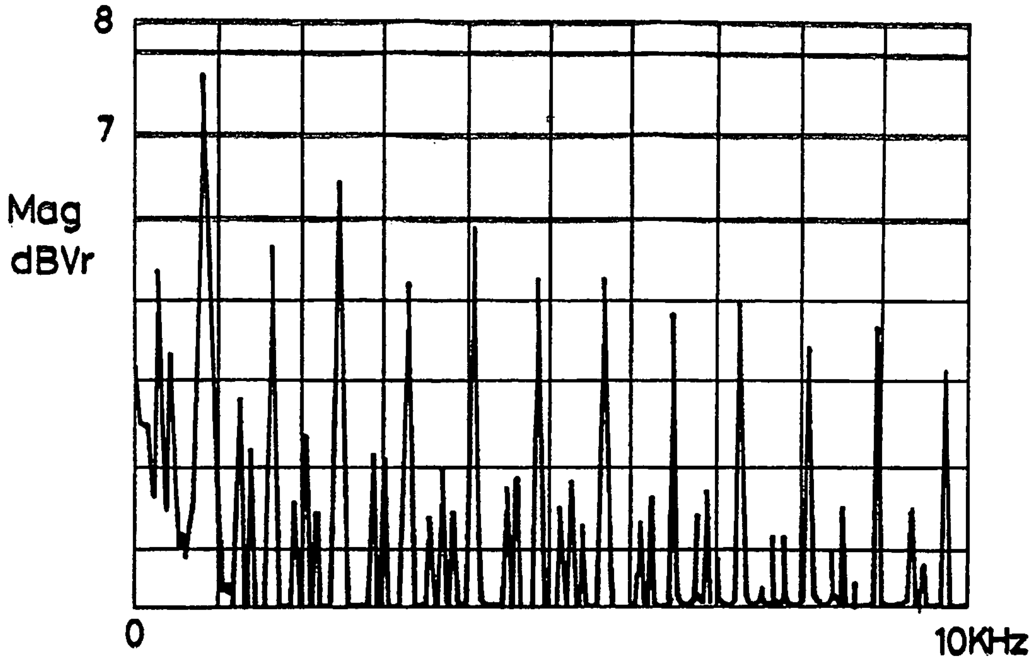
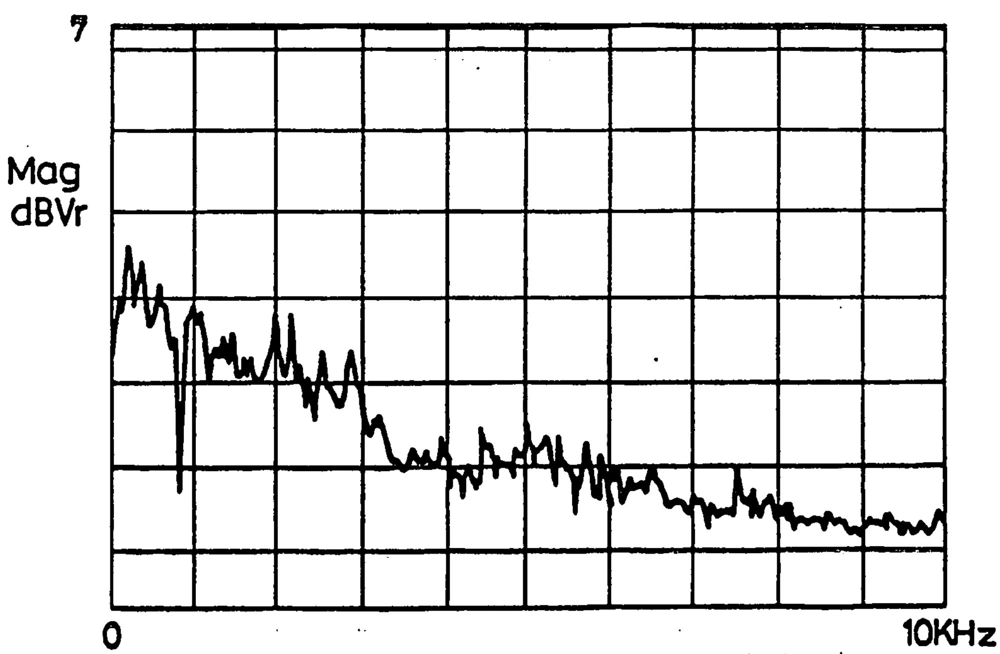


FIG. 12



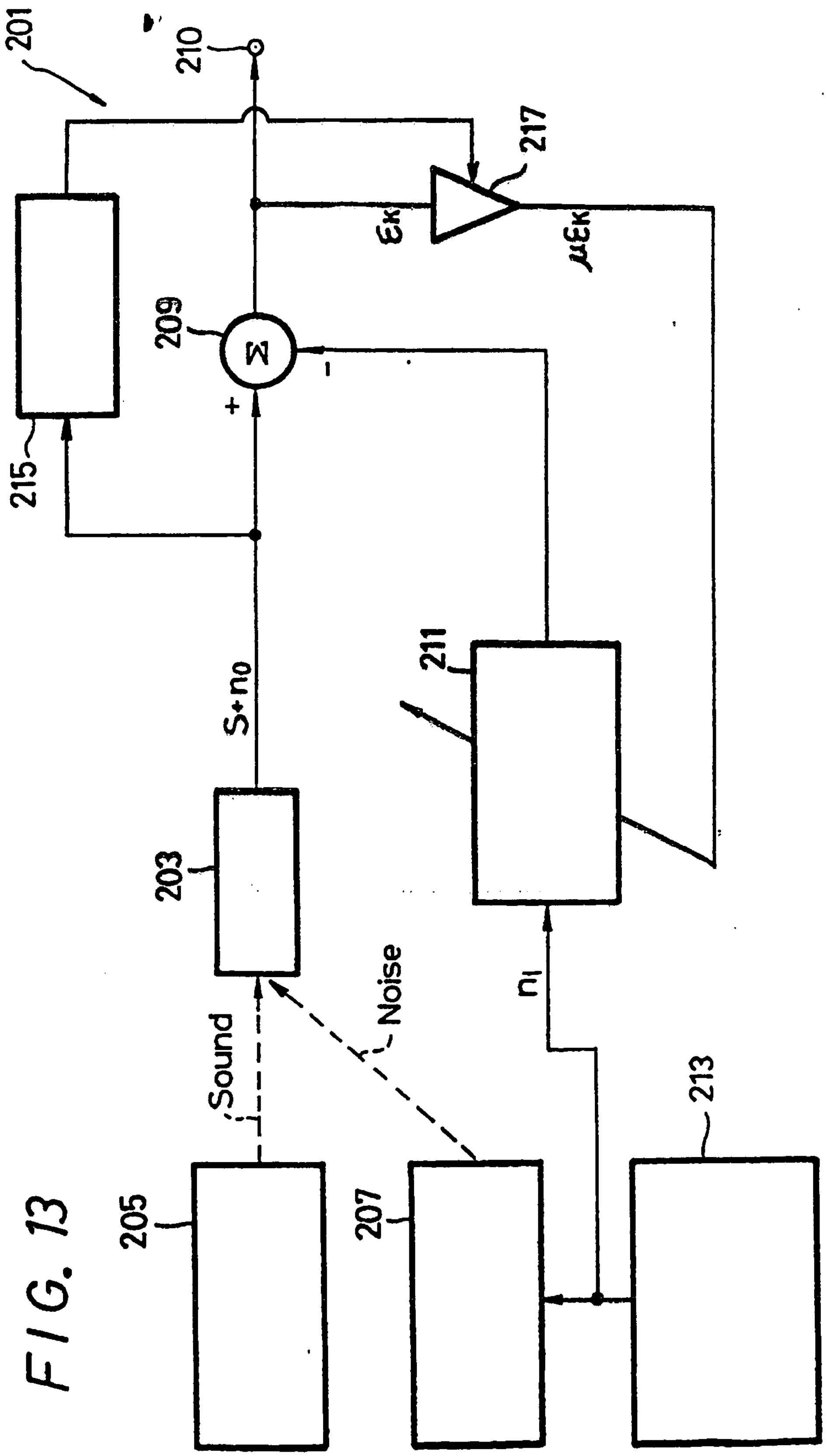


FIG. 13